

Sudden Natural Death

By Tala Tannous

SND

- ❖ WHO defines **SND** as:
death from natural diseases occurring **within 24 hours** of the onset of **symptoms**.
- ❖ But in forensic practice most sudden deaths occur **within minutes** or even **seconds** of the onset of symptoms and some will only accept death **within 1 hour** from the onset of illness as a sudden death.
- ❖ Indeed, it is very likely that a death that is delayed by hours will not be referred to medico-legal authorities, as a **diagnosis** may well have been made, and a death certificate can be completed by the attending doctors.

Sudden death

Unnatural

Suicidal / Homicidal / Accidental

Natural **Unexpected**

Sudden death of an individual:

1. With **no** known past medical history
2. With a known natural disease that **doesn't** explain death

Cardiovascular system

Cardiovascular system

- ❖ Sudden cardiac death (SCD): the unexpected natural death from a cardiac cause within a short time period, generally ≤ 1 hour from the onset of symptoms, in a person without any prior condition that would appear fatal.
- ❖ When a natural death is very rapid, the most common cause of irreversible cardiac arrest is a cardiovascular abnormality. While some degree of geographical variation is to be expected, the following lesions are the most significant as causes of sudden unexpected death.

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graph TD; A[Cardiovascular system] --> B[Diseases of the heart]; A --> C[Diseases of the heart valves]; A --> D[Diseases of the arteries];
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Cardiovascular system

Diseases of the heart

Diseases of the heart valves

Diseases of the arteries

Diseases of the heart

Coronary artery disease

Hypertensive heart disease

Aortic stenosis

Senile myocardial degeneration

Primary myocardial disease

Coronary arteries

Left Main Coronary Artery

The left main coronary artery branches into:

- ▶ Circumflex artery supplies blood to the left atrium, side and back of the left ventricle
- ▶ Left Anterior Descending artery (LAD) supplies the Anterior surface of the left ventricle and the anterior 2/3 of the interventricular-septum

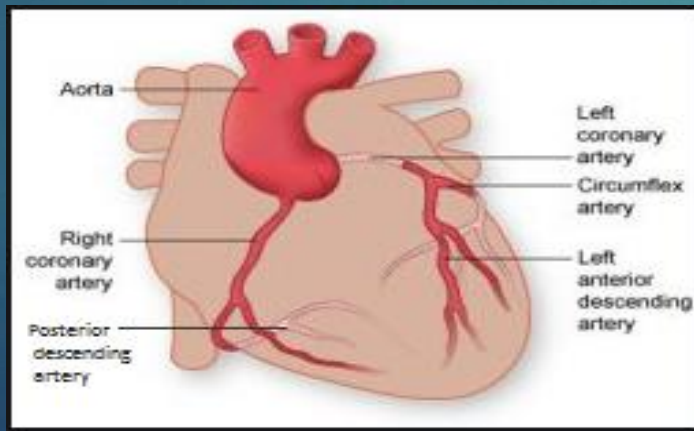
Right Coronary Artery (RCA)

The right coronary artery branches into:

- ▶ Right marginal artery
- ▶ Posterior descending artery

The right coronary artery supplies:

- ▶ SA node
- ▶ Right atrium and Right ventricle
- ▶ posterior 1/3 of interventricular septum, posterior 2/3 walls of ventricles, and posteromedial papillary muscle.



Coronary artery diseases

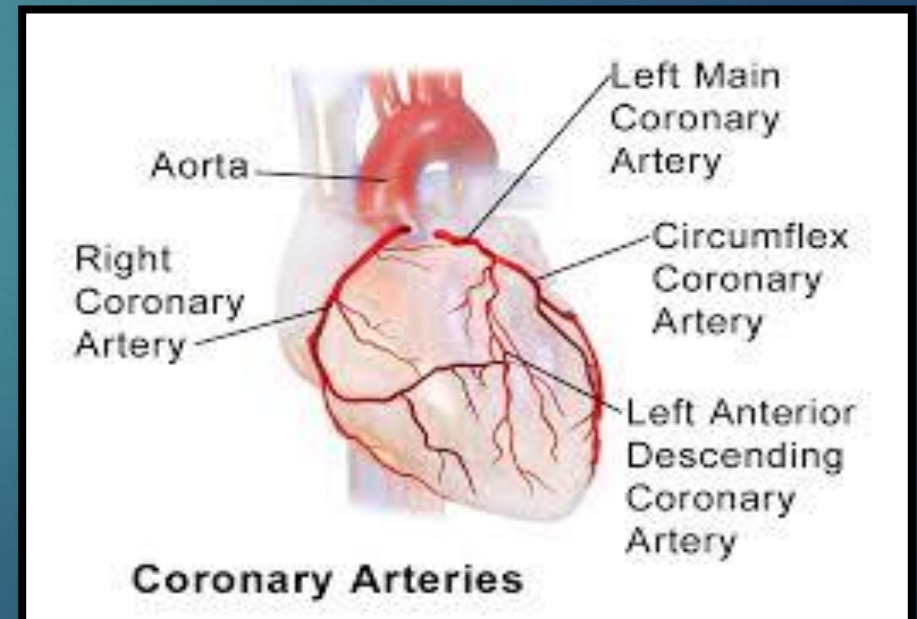
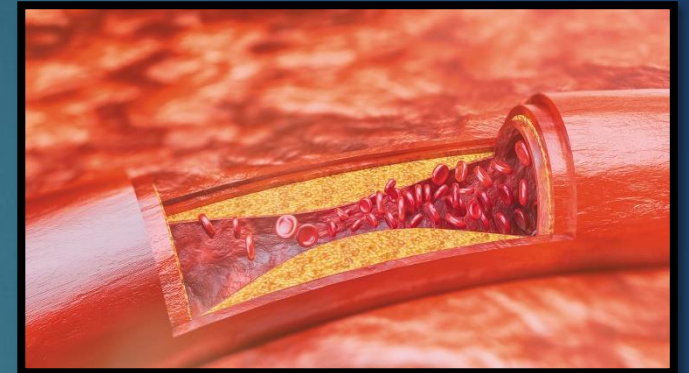
- ❖ Narrowing of the lumen of a coronary artery by atheroma may lead to chronic ischemia of the muscle supplied by that artery, predisposing to the development of an abnormal heart rhythm.
- ❖ The oxygen requirement of the myocardium is dependent upon the heart rate, if the increased oxygen demand cannot be met, the myocardium distal to the stenosis will become ischemic.
- ❖ Ischemia does not invariably lead to myocardial infarction, it just has to be sufficiently severe to initiate a **fatal arrhythmia** and, if the region rendered ischemic includes one of the pace-making nodes or a major branch the risk that rhythm abnormalities will develop is greatly increased.

Atherosclerosis

Myocardial infarction

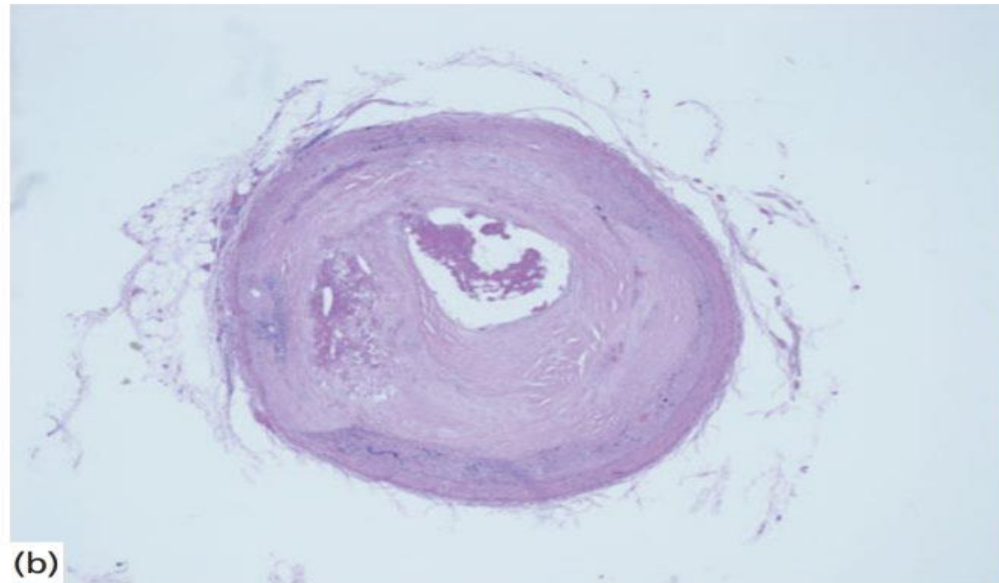
Coronary atherosclerosis

- ❖ A disease in which **plaque** builds up inside the coronary arteries.
- ❖ The **most common cause** of sudden natural death.
- ❖ **Most common sites of coronary artery occlusion** :
 - ❑ First 2 cm of the Left Anterior Descending Artery
 - ❑ Right Coronary Artery
 - ❑ Circumflex coronary artery





(a)

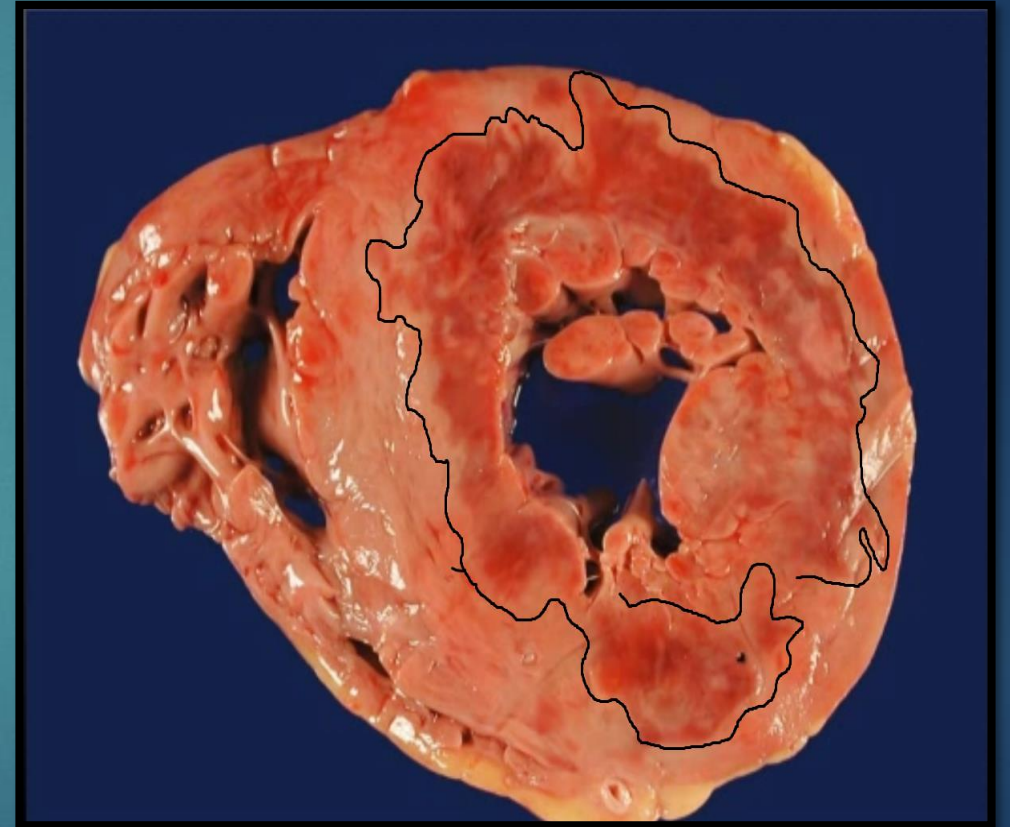


(b)

Figure 6.1 Significant coronary artery atherosclerosis and acute thrombosis. Macroscopic **(a)** and microscopic **(b)** appearance.

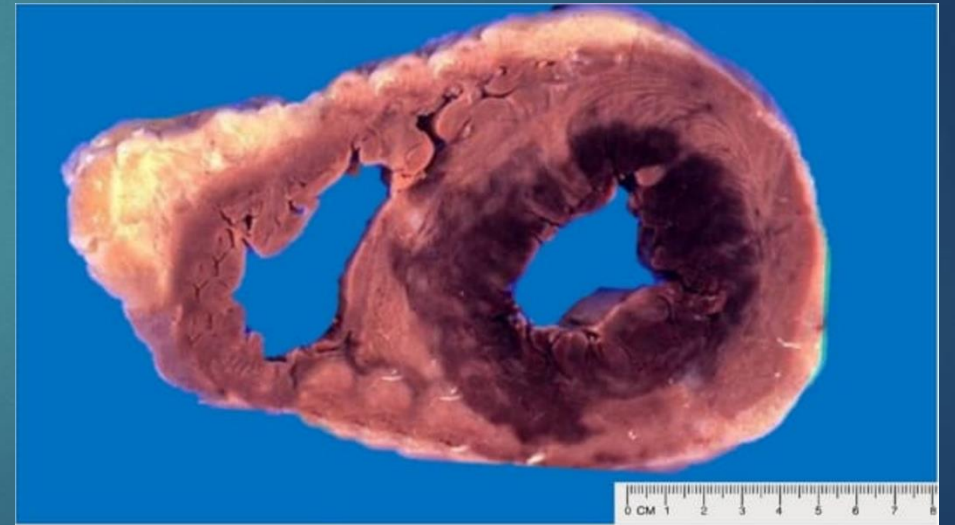
Myocardial infarction

- ❖ Myocardial infarction occurs when there is severe stenosis - 80% or more of the lumen of a coronary artery or a major branch.
- ❖ Blood supply is insufficient to maintain oxygenation of the myocardium.
- ❖ Death can be attributed to coronary artery disease (CAD) with less stenosis if other signs of chronic myocardial ischemia are apparent (left ventricular hypertrophy [LVH], fibrosis, previous infarct).
- ❖ An infarct heals by 'scarring' (fibrosis), and fibrotic plaques in the wall of the ventricle or septum may interfere with



Early Complications of MI

- ❖ In the first 24 hours, the most common complications are:
 - Ventricular fibrillation
 - Cardiogenic shock
- ❖ It should be noted that gross necrosis of the myocardium appears after 24 hours.
- ❖ Histopathological changes (necrosis) begin to appear on microscopy after 6 hours.



Late Complications of MI

1- Rupture of Myocardial Infarct

The area of the myocardial infarct is weakest between 3 days and 14 days after the clinical onset of the infarct, due to the beginning of the healing process using granulation tissue (which is relatively weak), and it is at this time that the weakened area of myocardium may rupture, leading to sudden death from :

- Hemopericardium
- Cardiac tamponade
- The rupture occasionally occurs through the interventricular septum, resulting in a left-right shunt

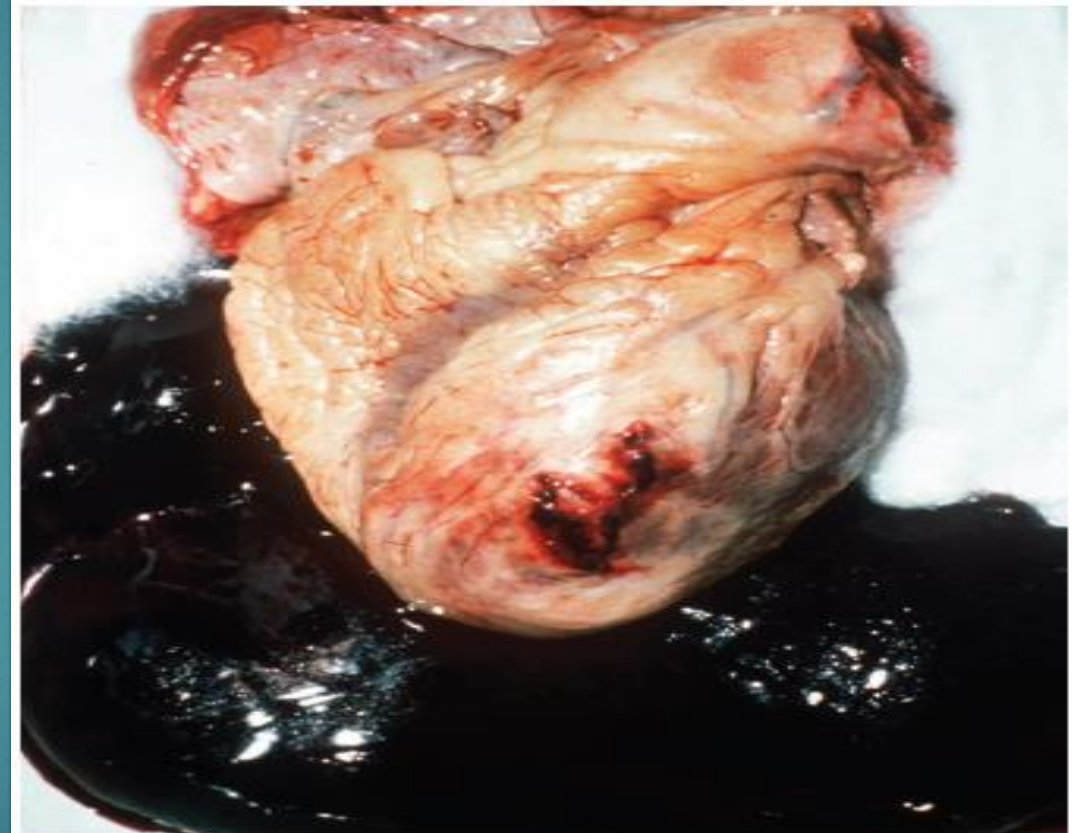
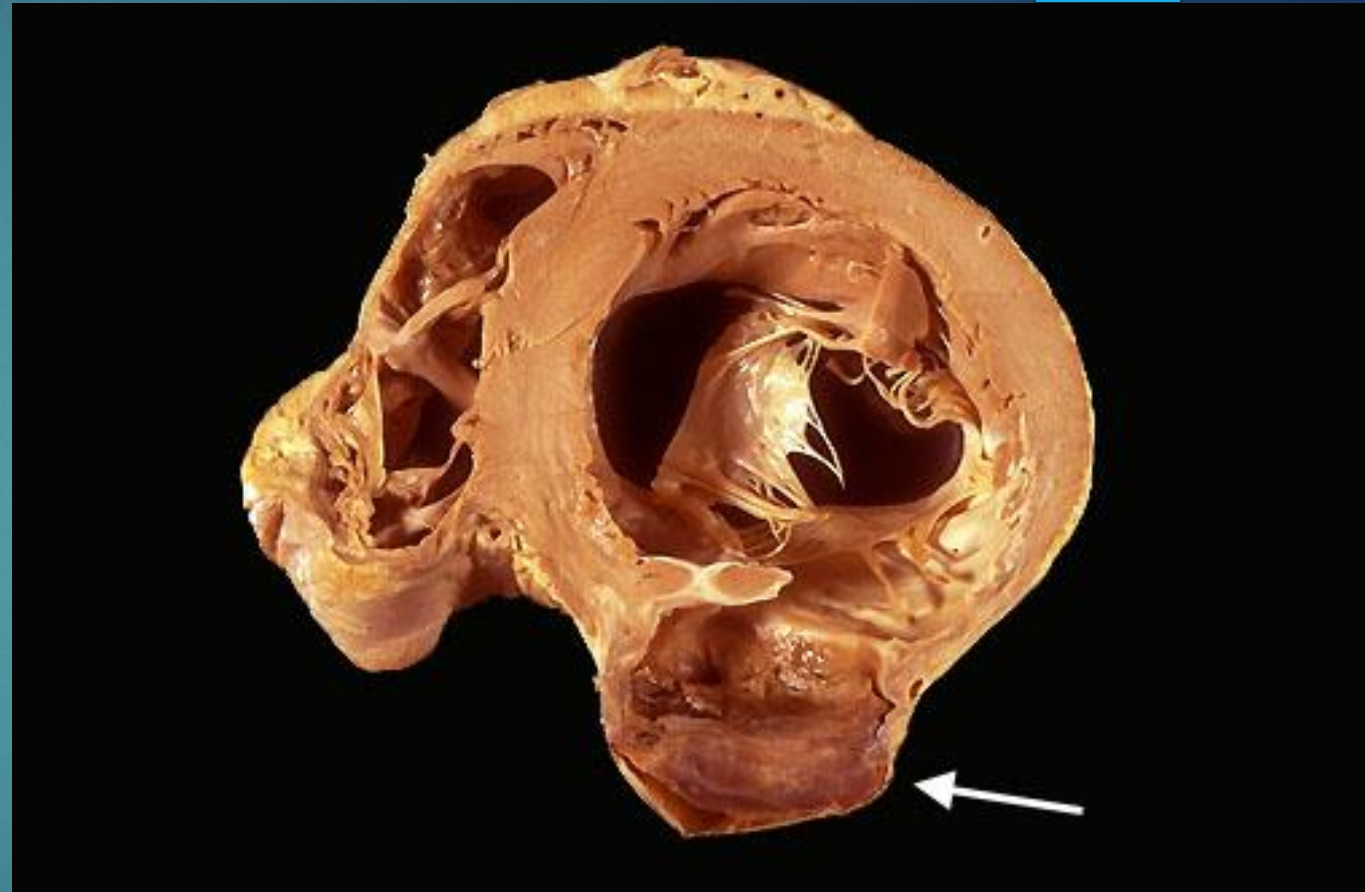


Figure 25.16 A haemopericardium due to a ruptured infarction of the left ventricular anterior wall. The large blood clot caused death from cardiac tamponade.

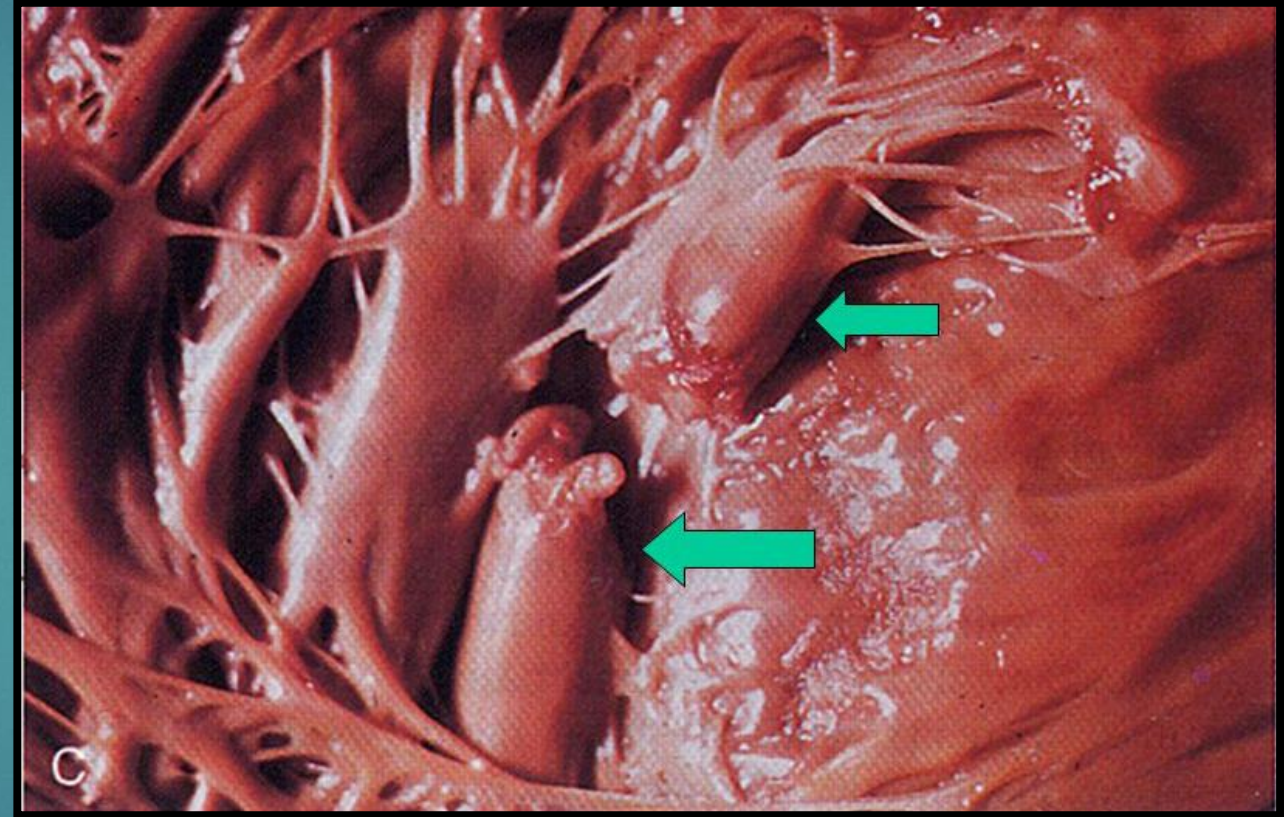
- ▶ **2- Cardiac Aneurysm :**
- ▶ **3-14 days post MI .**
- ▶ **May form at sites of infarction; they may calcify, and they may rupture.**



3- Papillary Muscle Rupture

:

- ▶ 2-7 days post MI.
- ▶ Allow part of the mitral valve to prolapse or may present as a sudden onset of valve insufficiency.



Hypertensive Heart Disease

- ❑ Long-standing hypertension can result in cardiac remodeling, manifested by left-ventricular hypertrophy (and cardiomegaly)
- ❑ An enlarged heart predisposes an individual to chronic myocardial hypoxia and electrical instability which, when combined with a 'trigger', can result in a fatal arrhythmia
- ❑ Some authors consider a heart weight of greater than 500 g to represent an inherently unstable heart
- ❑ Hypertensive heart disease often coexists with coronary artery atherosclerosis, and this increases the risk for the development of fatal arrhythmias at times of cardiovascular 'stress'

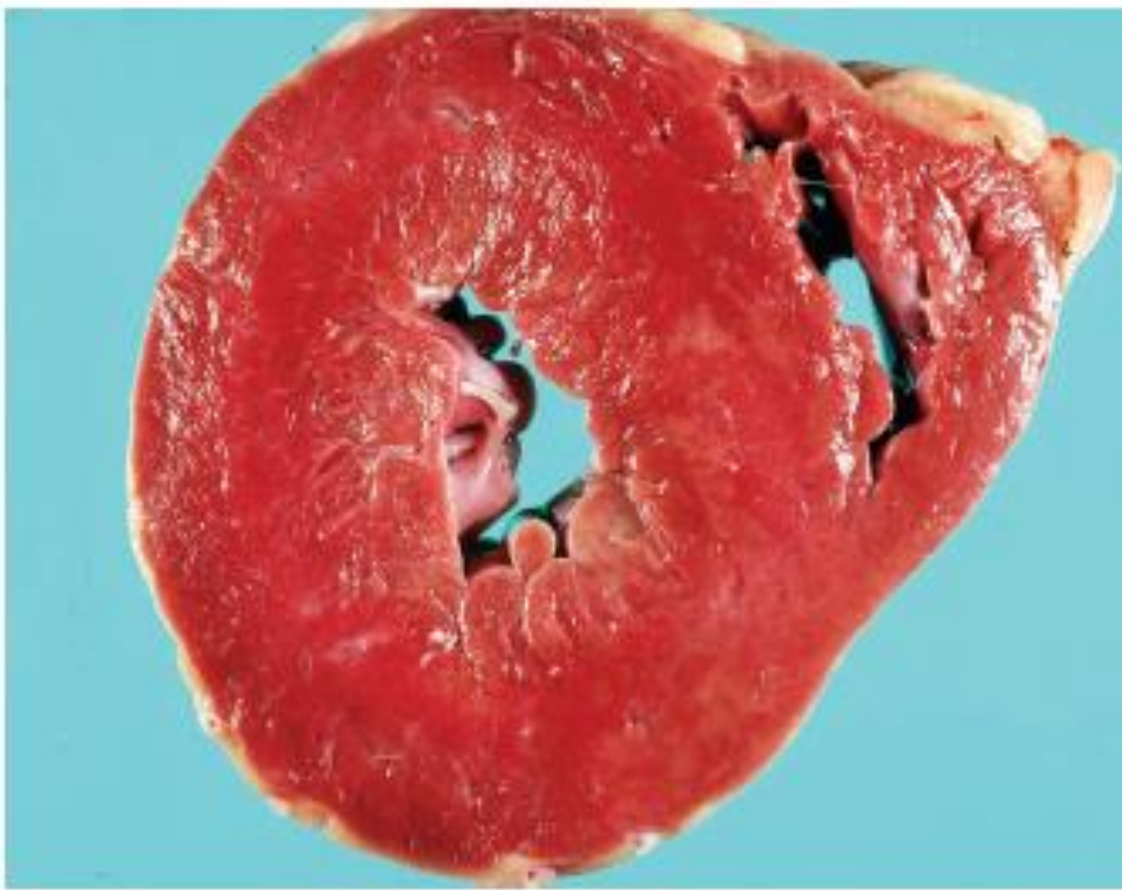
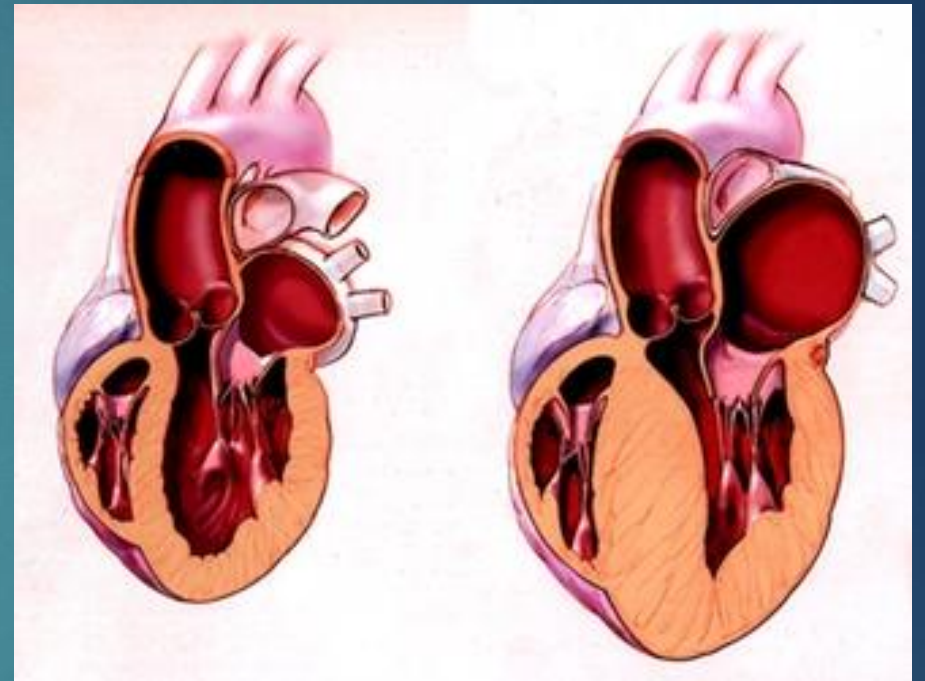


Figure 25.19 Concentric hypertrophy of the left ventricle in a person with cardiomegaly from hypertension. The slice has been stained with triphenyl tetrazolium chloride to reveal dehydrogenase activity; some mottled areas, especially in the septum, show pallor from reduced enzyme activity as a result of relative ischaemia of the increased muscle mass.



Aortic Stenosis

- ❑ Classically affects older individuals with calcified aortic valves
- ❑ May also be seen in younger people who have a congenital bicuspid aortic valve.
- ❑ The accompanying myocardial hypertrophy is similar to that caused by hypertension – leading to left ventricular hypertrophy which may, in some cases produce heart weights of over 700 g.
- ❑ In aortic stenosis, myocardial perfusion is worsened by the narrow valve, which results in a lower pressure at the coronary ostia and hence in the coronary arteries.
- ❑ Sudden death is common.

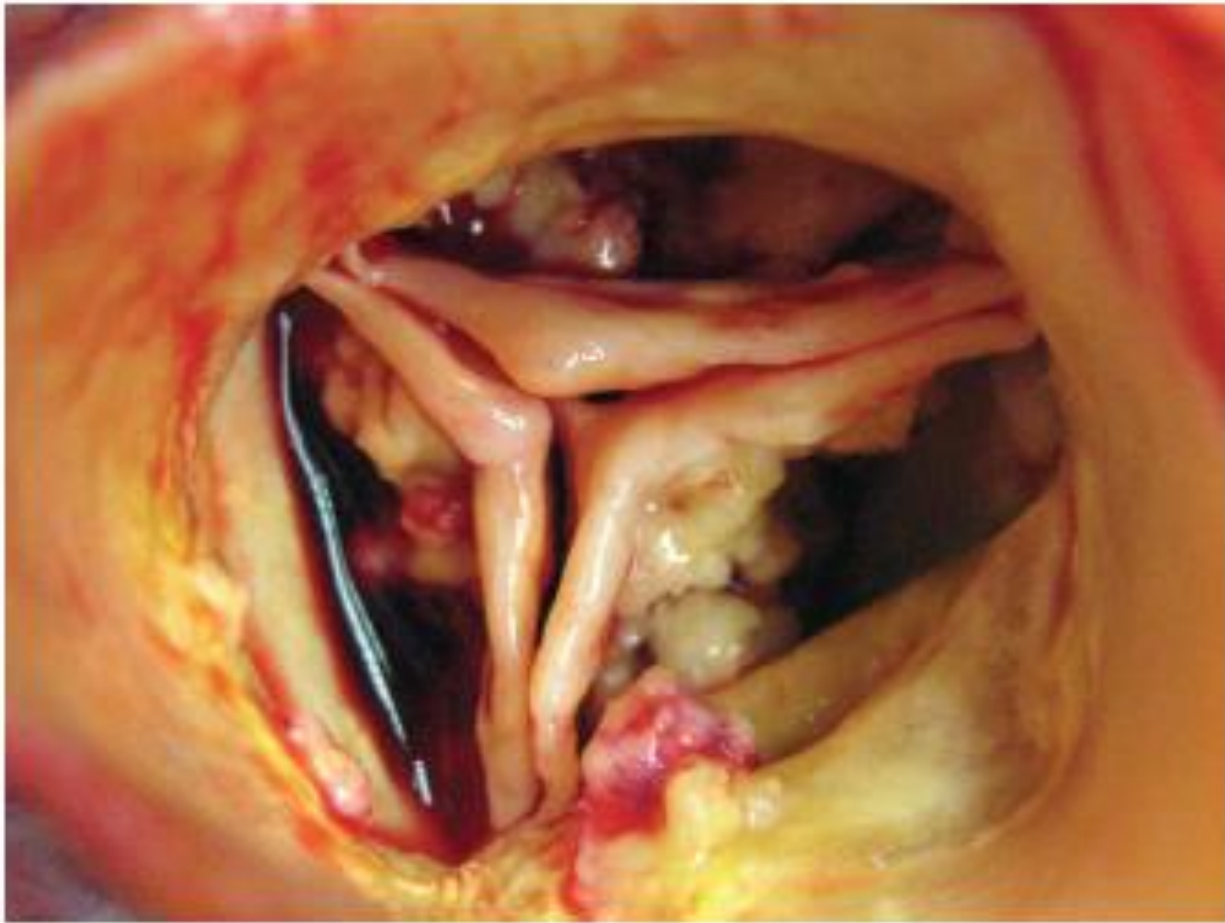


Figure 25.20 Calcific aortic stenosis, a common cause of sudden unexpected death especially in older males. Marked left ventricular hypertrophy usually ensues, the large muscle mass becoming ischaemic, especially in the inner layers.

AORTIC STENOSIS

Normal Aortic Valves



open

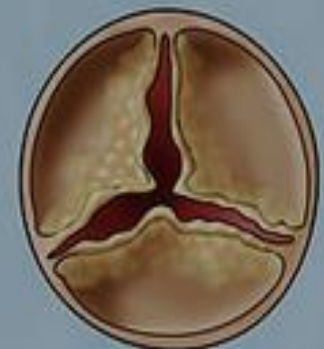


closed

Aortic Valve Stenosis



open



closed

Senile myocardial degeneration

- ❑ **Senescence** is a well-accepted concept in all animals, and few humans survive beyond 90 –100 years.
- ❑ The cause of a sudden death in these elderly individuals can be very difficult to determine.
- ❑ The senile heart is **small**, the surface vessels are **tortuous**, and the myocardium is **soft** and **brown** owing to accumulated **lipofuscin** in the cells.

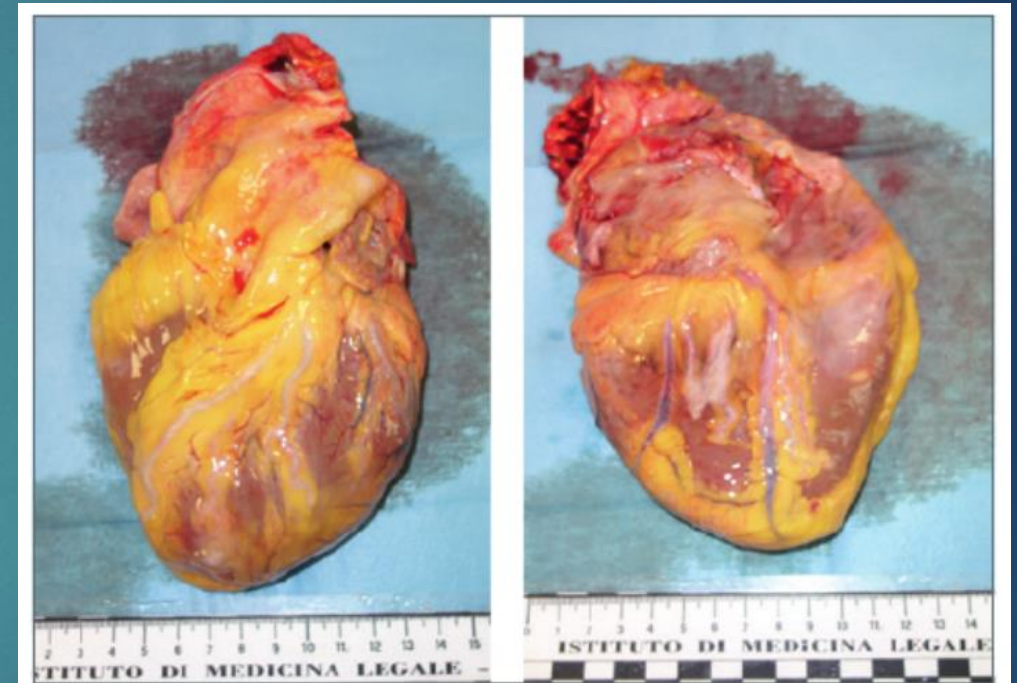


Figure 1. Senile myocardium of a man 94 years old.

Primary Myocardial Disease

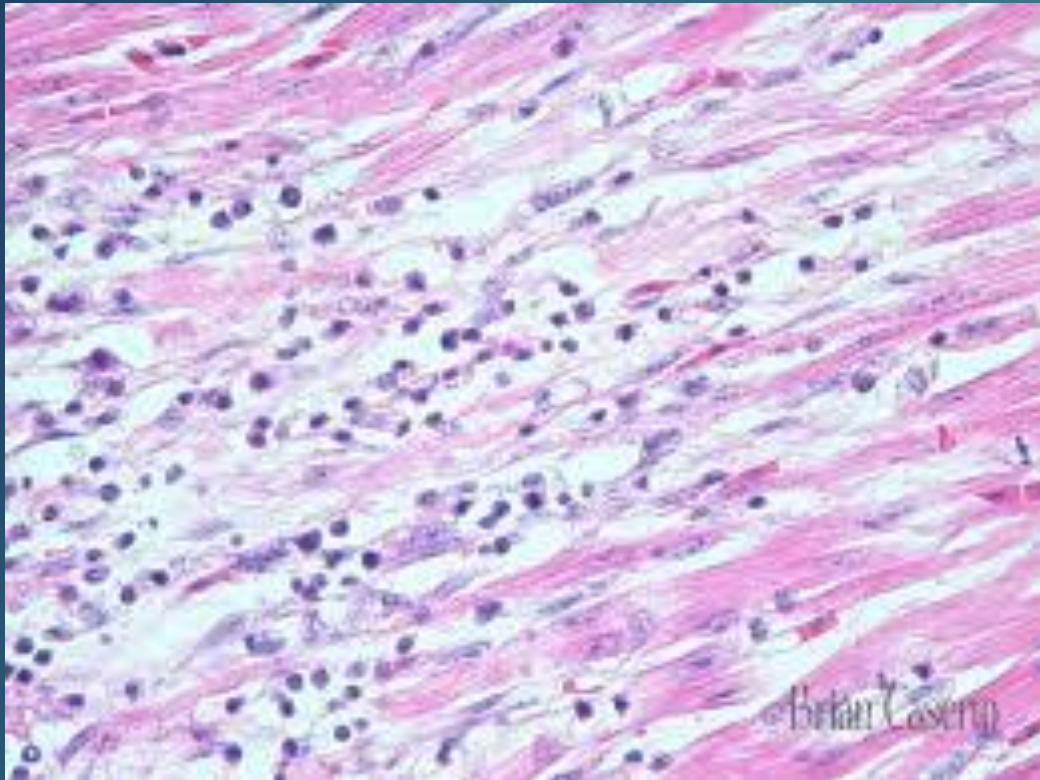
- Primary diseases of the myocardium are much less common than the degenerative conditions, and they commonly affect a significantly younger age group.

- They include:
 - a) Conditions where there is a structural abnormality of the heart that is visible to the 'naked eye' and/or under the microscope (*Myocarditis and 'Cardiomyopathies'*)
 - b) Conditions having no recognizable morphological/structural abnormality (*'Channelopathies'*).

1 - Myocarditis:

(Classic patient is young adult < 40)

- ❑ Myocarditis occurs in many **infective** diseases, such as diphtheria and **viral** infection (most common).
- ❑ The **clinical** manifestation of the acute picture may range from none to acute heart failure to sudden death.
- ❑ Sudden death may occur some **days** or even **weeks** after the main clinical symptoms .
- ❑ Sometimes: macroscopically pale or hemorrhagic foci in the myocardium (having a '**mottled**' appearance)
- ❑ **Histological confirmation** of multifocal inflammatory cell infiltrates and associated myocyte necrosis requires extensive sampling at post-mortem examination.
- ❑ In sudden death pathology, a myocarditis of unknown etiology is sometimes discovered incidentally on histology of autopsy tissues, known as isolated, **Fiedler's** or **Saphir's myocarditis**.
- ▶ **Complications** include sudden death, arrhythmias, heart block, mural thrombus with systemic emboli.



Histopathology show **lymphocytic** infiltrate with focal necrosis highly indicative of **viral** myocarditis.

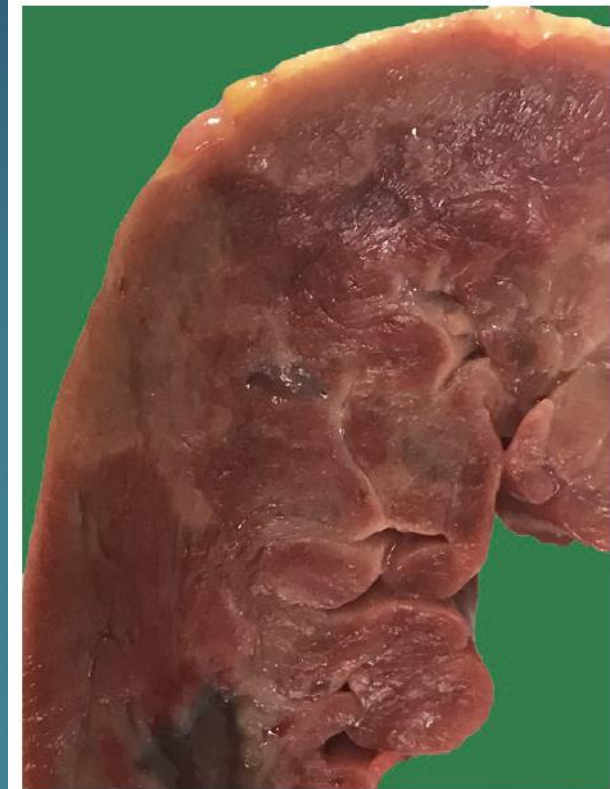


Fig. 2 Close up macroscopic view of a case of myocarditis showing a mottled appearance, not aligned to a vascular territory. This is clearly different to infarction as in early myocarditis

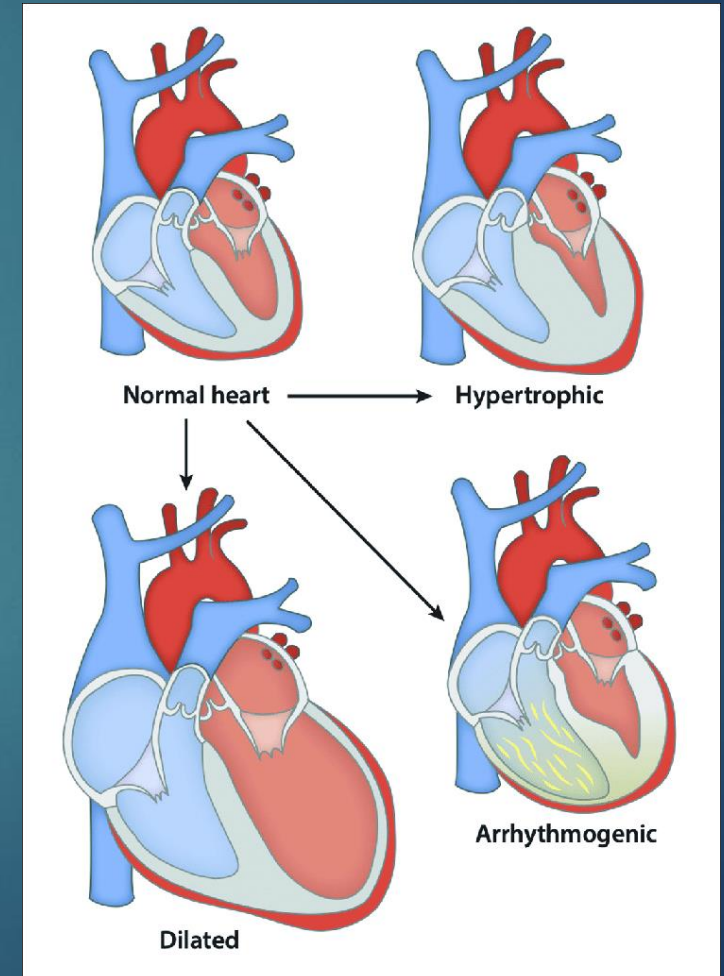
Myocarditis **cannot** be diagnosed without microscopy but sometimes the macroscopic appearance of the myocardium may **suggest** an on-going pathological process; like pale, **mottled** and edematous myocardium

2- Cardiomyopathies (CM):

❑ Cardiomyopathies are an important group of conditions linked to sudden death in the young and are of particular importance in deaths occurring during exercise, or on the athletic field.

❑ Types of cardiomyopathies :

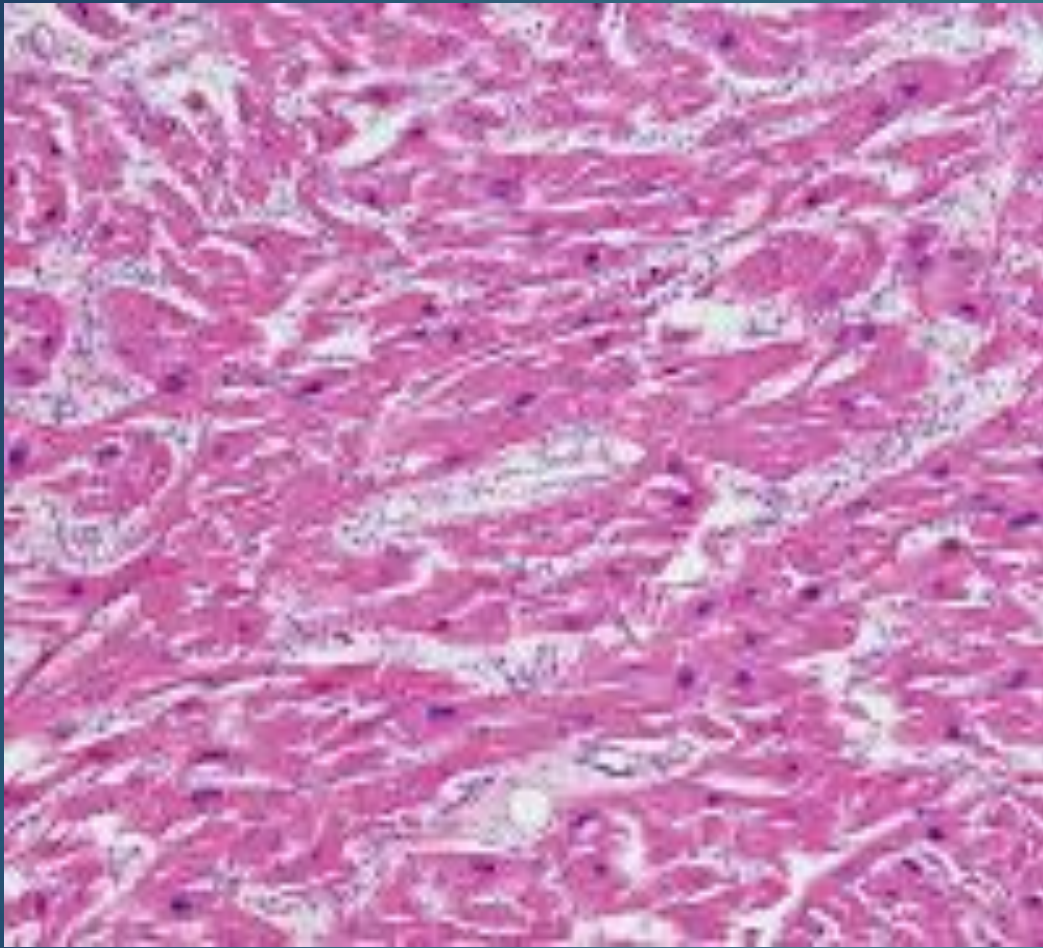
- Hypertrophic CM
- Dilated CM
- Arrhythmogenic Right Ventricular CM (ARVCM)
- Restrictive CM



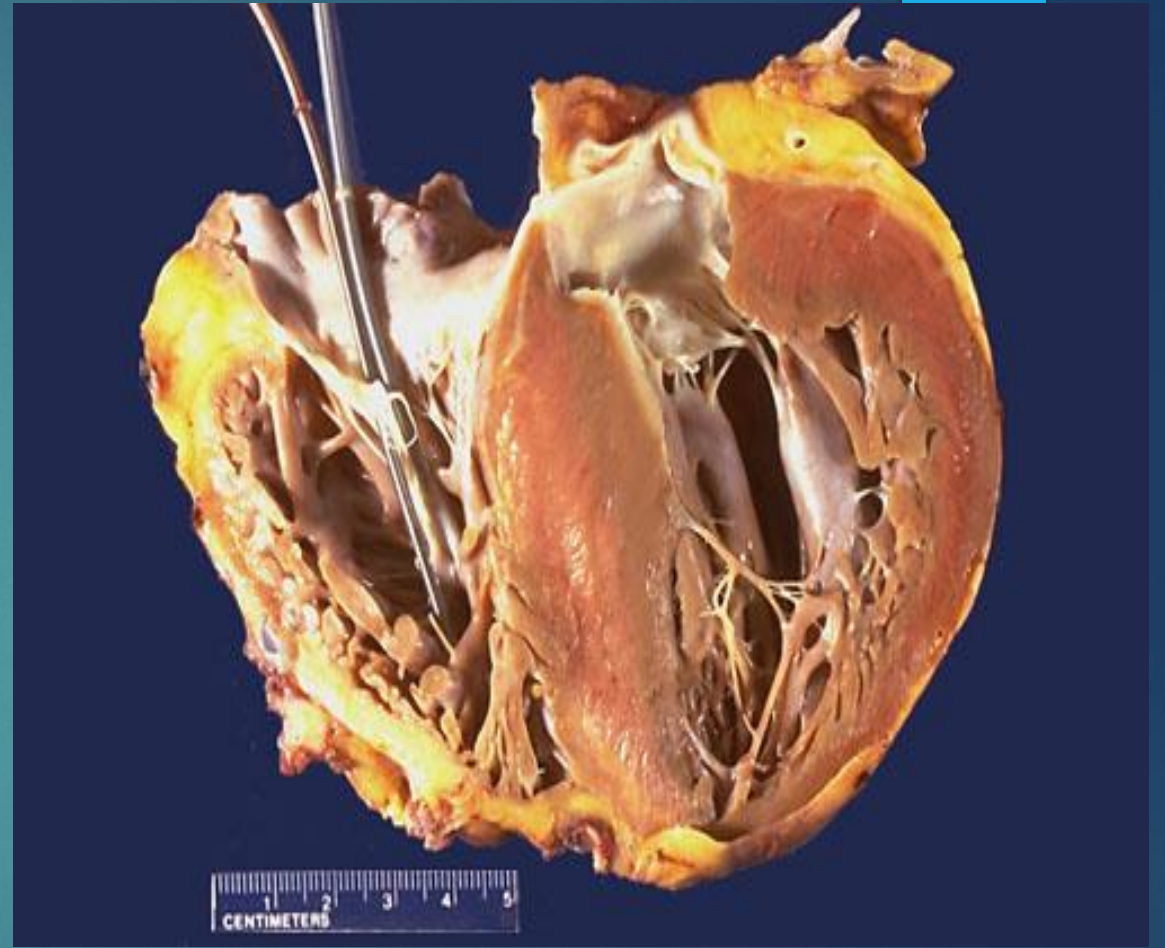
2- Cardiomyopathies (CM):

❖ Hypertrophic cardiomyopathy (HCM):

- ❑ Inherited (AD) or sporadic
- ❑ Disease of cardiac muscle sarcomeric proteins, that causes asymmetrical hypertrophy, and characterized by myocyte disarray. This leads to stiff ventricle → decreased compliance {diastolic dysfunction}.
- ❑ Leading cause of sudden cardiac death in young athletes
- ❑ Sudden death is mainly due to ventricular fibrillation and may be the first manifestation.



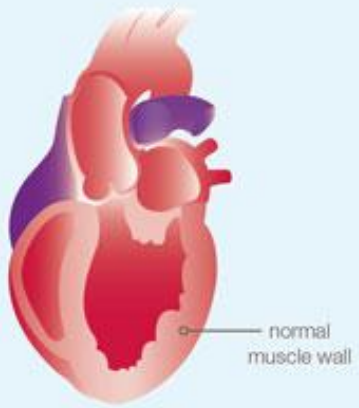
Fibrosis and myocardial **disarray**
in hypertrophic cardiomyopathy.



Asymmetric massive
thickening of ventricular
walls.

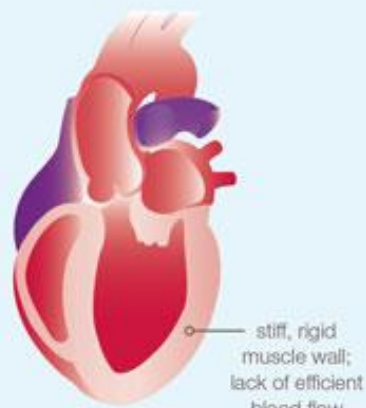
2- Cardiomyopathies (CM):

- ❖ Dilated cardiomyopathy (DCM) [the most common type]:
 - ❑ Primary or secondary (Chronic alcohol abuse, pregnancy, etc.)
 - ❑ Diminished contractility of ventricles
 - ❑ Systolic dysfunction & causes heart failure
- ❖ Arrhythmogenic right ventricular cardiomyopathy (ARVC):
 - ❑ an inherited condition which is characterized by predominantly right-ventricular thinning with fibro-fatty myocyte replacement.
- ❖ Restrictive cardiomyopathy (RCM):
 - ❑ Decreased compliance of the ventricular endomyocardium that restricts filling during diastole
 - ❑ Death is due to diastolic dysfunction
 - ❑ Associated with: amyloidosis , sarcoidosis , post-radiation fibrosis and hemochromatosis.



normal muscle wall

Normal Heart

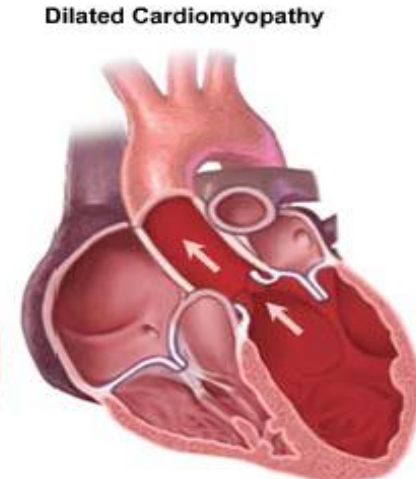


stiff, rigid muscle wall; lack of efficient blood flow

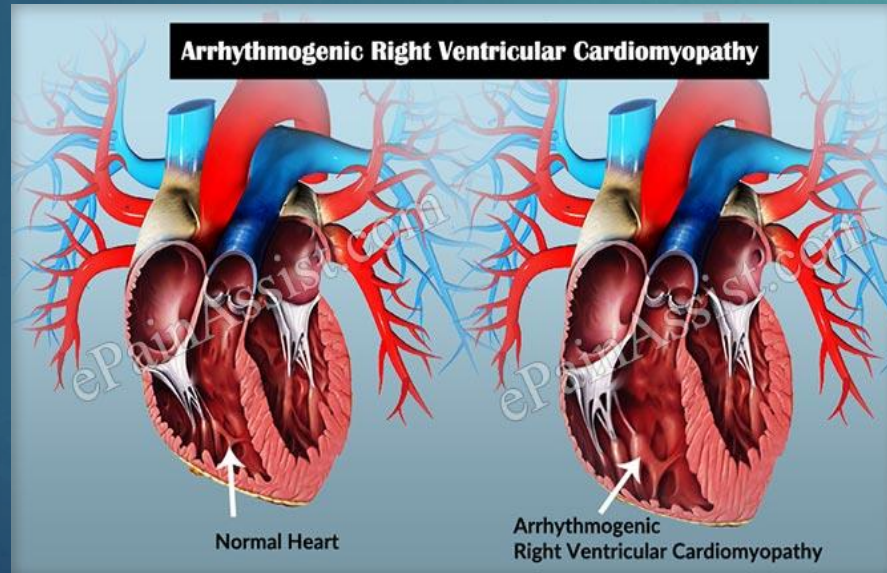
Heart with Restrictive Cardiomyopathy



Normal



Dilated Cardiomyopathy



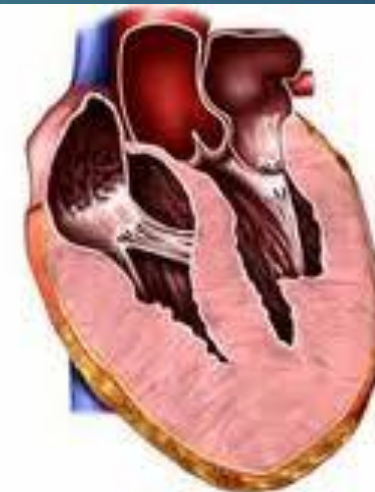
Arrhythmogenic Right Ventricular Cardiomyopathy

Normal Heart

Arrhythmogenic Right Ventricular Cardiomyopathy



Normal heart (cut section)



Hypertrophic cardiomyopathy

3- Channelopathies (functional abnormality)

- ❖ They are a group of disorders that represent a relatively small proportion of sudden deaths, presumed to be of cardiac origin, where investigations have failed to identify an alternative explanation for death.
- ❖ Pathologically, there are no 'naked eye' or microscopic abnormalities in the heart as the defects are at a molecular level.
- ❖ Defects in genes encoding myocyte contractile units have been characterized, and these affect the function of sodium, potassium and calcium channels (hence 'channelopathies').
- ❖ This has recently increased the role of post-mortem molecular investigations

3- Channelopathies (functional abnormality)

- These sudden deaths are often 'triggered' by a stimulus, including exercise, sudden loud noises or even during sleep. Such deaths are often characterized as falling into the broad category of sudden adult death syndrome (SADS).
- Other entities of SADS include:
 - Wolff-Parkinson-white syndrome
 - Long QT syndrome (LQTS).
 - Idiopathic Ventricular Fibrillation
 - short QT syndrome (SQTS).
 - Brugada syndrome

Diseases of the Arteries

- ❖ The most common lesion of (extra-cardiac) arteries associated with sudden death is the aneurysm.
- ❖ Atheromatous aneurysm of the aorta:
 - ❑ These aneurysms are most commonly found in elderly individuals in the abdominal region of the aorta
 - ❑ Formed when the elastic component of the aortic wall underlying an atheromatous plaque is damaged and blood under pressure is able to 'balloon' the weakened wall.
 - ❑ Could be incidental finding at autopsy or rupture and cause death
 - ❑ The rupture may be repaired surgically if diagnosed in time, but many individuals die too quickly for any help to be given. Because the aorta lies in the retroperitoneal space, that is where the bleeding is found; it may lie to one side and envelop a kidney

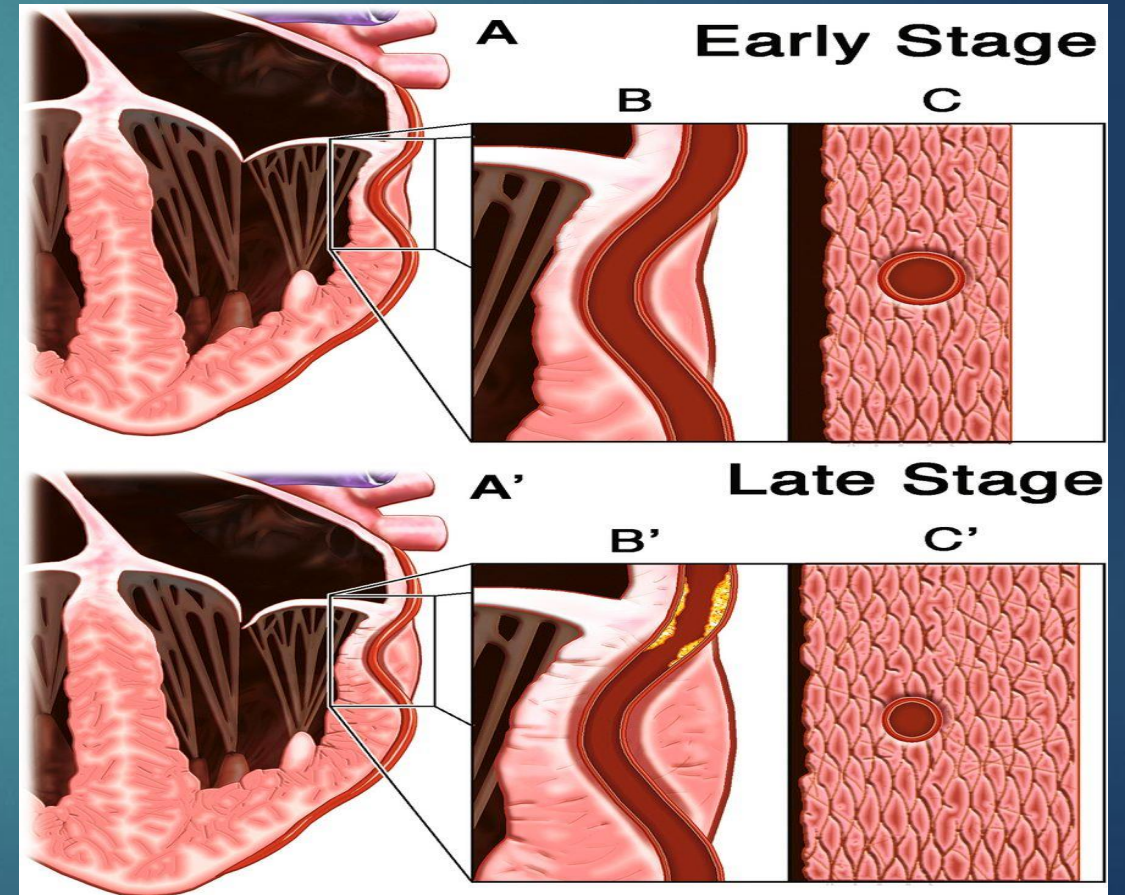
Diseases of the Arteries

❖ Aortic dissection:

- ❑ The commonest site of origin is in the **thoracic** aorta (proximal 10 cm) and the dissection usually tracks distally towards the abdominal region. It can produce a hemopericardium, cardiac tamponade and sudden death.
- ❑ Other causes of death: MI, hypovolemic shock and it may reach cerebral arteries.
- ❑ Aortic dissection are principally found in individuals with **hypertension** but may also be seen in younger individuals with connective tissue defects, such as **Marfan syndrome**.

Myocardial Bridging

- ❑ Sudden death due to coronary artery abnormalities.
- ❑ The left anterior descending coronary artery instead of lying in the epicardial fat of heart, dips down into myocardium becoming vulnerable for compression during heart contraction.



Valvular heart diseases



Calcific aortic stenosis: valve is thickened & rigid with fusion of commissure

- ❑ Rheumatic heart disease
- ❑ Bicuspid aortic valve
- ❑ Mitral valve prolapse
- ❑ Bacterial endocarditis



Destruction of the mitral valve, with extensive vegetations (arrows) from infectious endocarditis

The most common causes of sudden Cardiac death:

- ▶ 1st: Atherosclerosis in coronary arteries
- ▶ 2nd: Cardiomyopathies
- ▶ 3rd: Channelopathies
- ▶ 4th: Myocarditis

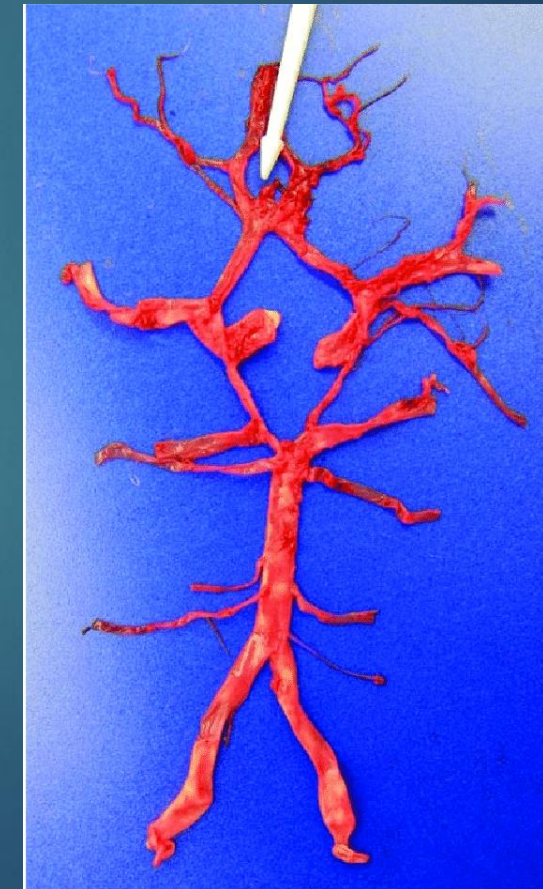
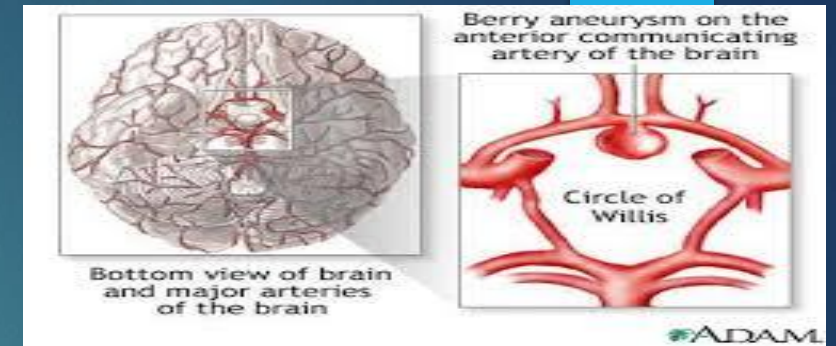
Central Nervous System

Causes:

- 1-Ruptured berry aneurysm
- 2-Epilepsy (**most common**)
- 3-Subarachnoid hemorrhage
- 4-Cerebral thrombosis and infarction
- 5-Infection (meningitis)
- 6-Tumors

Rupture of Berry Aneurysm

- ❑ Berry aneurysm (saccular aneurysm) : occurs at bifurcations in the circle of willis.
- ❑ Any rise in the blood pressure will cause rupture of the apex of the aneurysm.
- ❑ It will cause subarachnoid hemorrhage and rapid collapse and death
- ❑ The precise mechanism of sudden death following subarachnoid haemorrhage is not understood bathing the brain-stem in blood may invoke vascular spasm resulting in critical ischaemia of cardiorespiratory control centres or the presence of subarachnoid blood under pressure may directly affect such brain-stem cardiorespiratory control.
- ❑ Ruptured berry aneurysm is one of the most common causes of death in young to middle-aged adults, if coronary disease is excluded.






Epilepsy

- **Epilepsy** – recurrent unprovoked seizures – is associated with an increased risk of mortality
- Sudden unexpected death in Epilepsy (**SUDEP**) , The sudden, unexpected, and **nontraumatic** death of person with epilepsy in whom the postmortem examination fails to reveal a gross anatomical ,toxicological or environmental cause of death; the event may be witnessed or unwitnessed and can occur with or without evidence of a seizure {excluding documented **status epilepticus**}.
- May be **related** to a seizure-induced arrhythmia, seizure-mediated inhibition of respiratory centers or a complication of anti-epileptic treatment.

SUDDEN UNEXPECTED DEATH IN EPILEPSY (SUDEP)

RISK FACTORS

-  Generalized tonic-clonic seizures
-  Not taking medication as prescribed
-  Early age of epilepsy onset
-  Uncontrolled or frequent seizures

CURE EPILEPSY

SUDEP ACTION DAY
#TIME2CHANGE

Source: cdc.gov/epilepsy/about/sudep

Cerebral thrombosis and Infarction

- ❑ A **cerebral infarction** is an area of necrotic tissue in the brain resulting from a blockage or narrowing in the arteries supplying blood and oxygen to the brain. The blockage can be due to a thrombus, an embolus or an atheromatous stenosis of one or more arteries.
- ❑ Sudden bleeding into brain tissue is common, usually in **old age** and in those with significant **hypertension** and, together with cerebral thrombosis and resulting brain infarction, is the commonest cause of the well-recognized cluster of neurological signs colloquially termed a '**stroke**'
- ❑ If a large stroke happens in a part of the brain **vital** to breathing or the heart, it can lead to death in a short time. If the stroke is very large, it can cause widespread damage that the brain can't survive even if the cause of a clot or a bleed is treated.

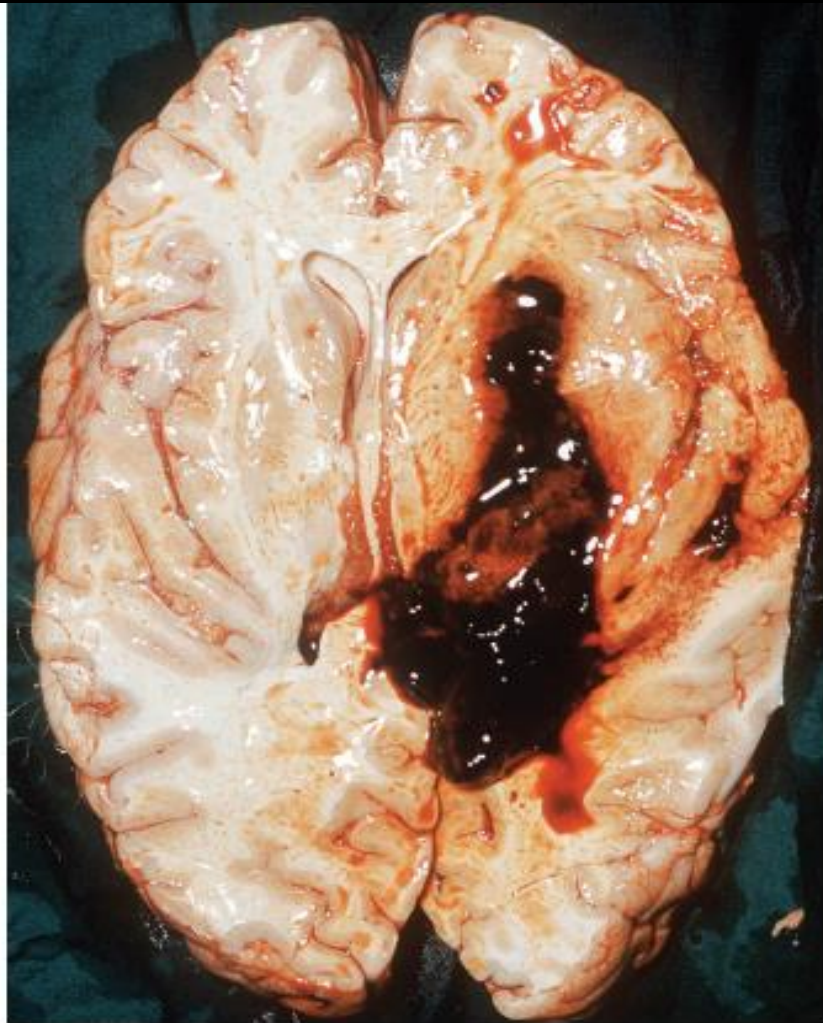


Figure 25.32 A large recent intracerebral haemorrhage in a person with hypertension. The bleeding has originated in the region of the external capsule from a lenticulostriate branch of the middle cerebral artery, then broken through into the posterior horn of the lateral ventricle.



Figure 25.33 A massive pontine haemorrhage in a person with hypertension.

Infection

- ▶ **Meningitis:** brain damage in bacterial meningitis leading to long-term neurologic sequelae and death is caused by several mechanisms. Bacterial invasion and the release of bacterial compounds promote inflammation, finally leading to cell death.
- ▶ **Encephalitis:** is a serious neurological condition and unfortunately, despite improvements in specific and more supportive treatments such as excellent intensive care management, it still has a high mortality (death) rate. When death happens it is usually because of the brain swelling as a result of its severe inflammation.

Respiratory System

Causes:

1-Pulmonary embolism (**most common**)

2-Asthma

3-Pneumonia

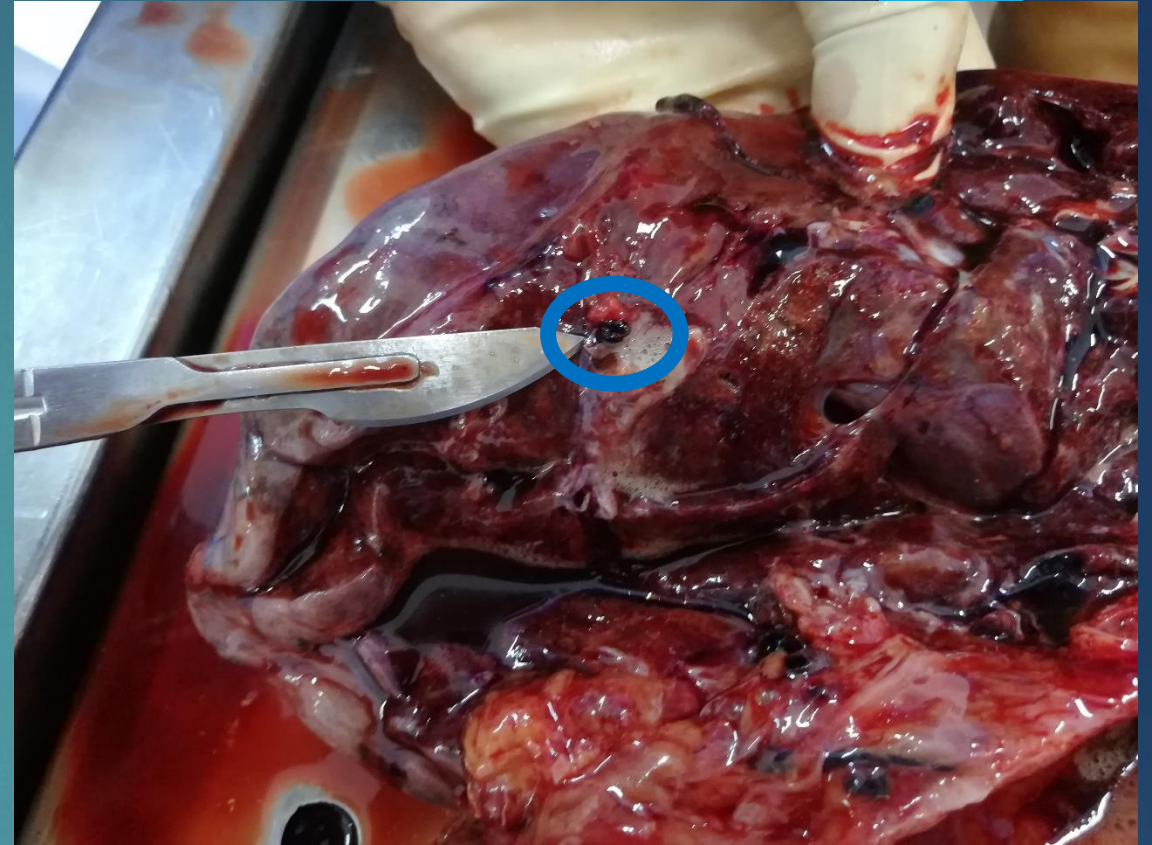
4-Massive hemoptysis

Pulmonary embolism

- ❑ The most clinically **under-diagnosed** cause of death therefore, the disease remains a major health problem.
- ❑ The source of the emboli is in the deep leg or pelvic veins
- ❑ Tissue **trauma**, especially where it is associated with **immobility** or bed rest, is a very common predisposing factor in the development of **deep vein thrombosis**.
- **Large thromboemboli** can occlude the origin of the pulmonary arteries (**saddle emboli**), resulting in massive acute right-heart strain and failure as a result of mechanical blockage
- **Smaller thromboemboli** become lodged in smaller-calibre pulmonary blood vessels where they interfere with pulmonary function and lead to myocardial ischaemia and cardiac arrest.



A Large thromboemboli occluding the origin of the pulmonary arteries that can be seen directly after opening the right ventricle

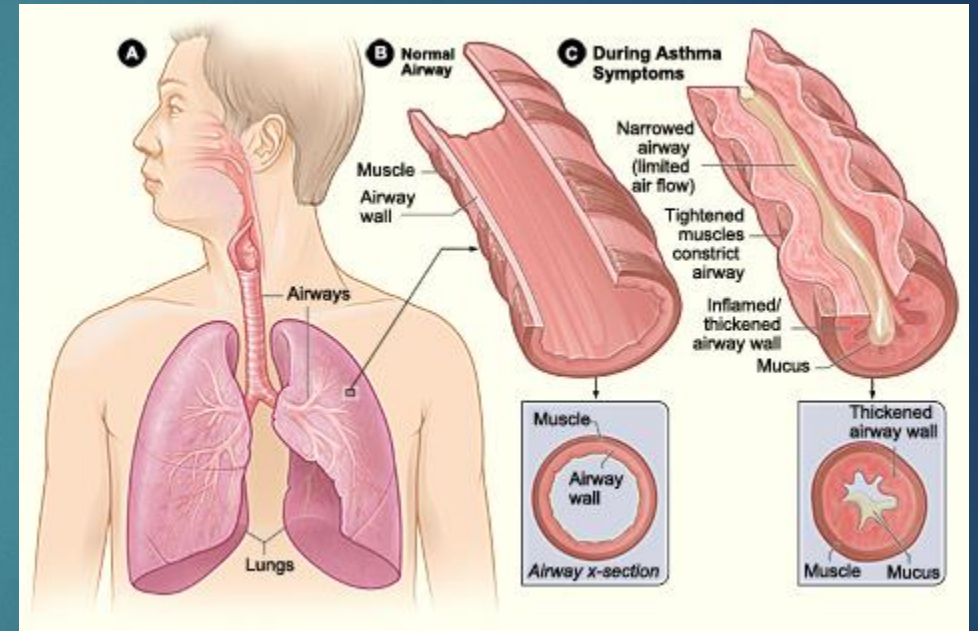


A Small thromboemboli occluding one of the small branches of the pulmonary arteries inside lung parenchyma

Asthma

Death from asthma generally occurs in the setting of a prolonged asthma attack worsening over days or weeks and may be preceded by "status asthmaticus".

Death may also occur due to hypoxia or respiratory acidosis.





Gastrointestinal system

Causes:

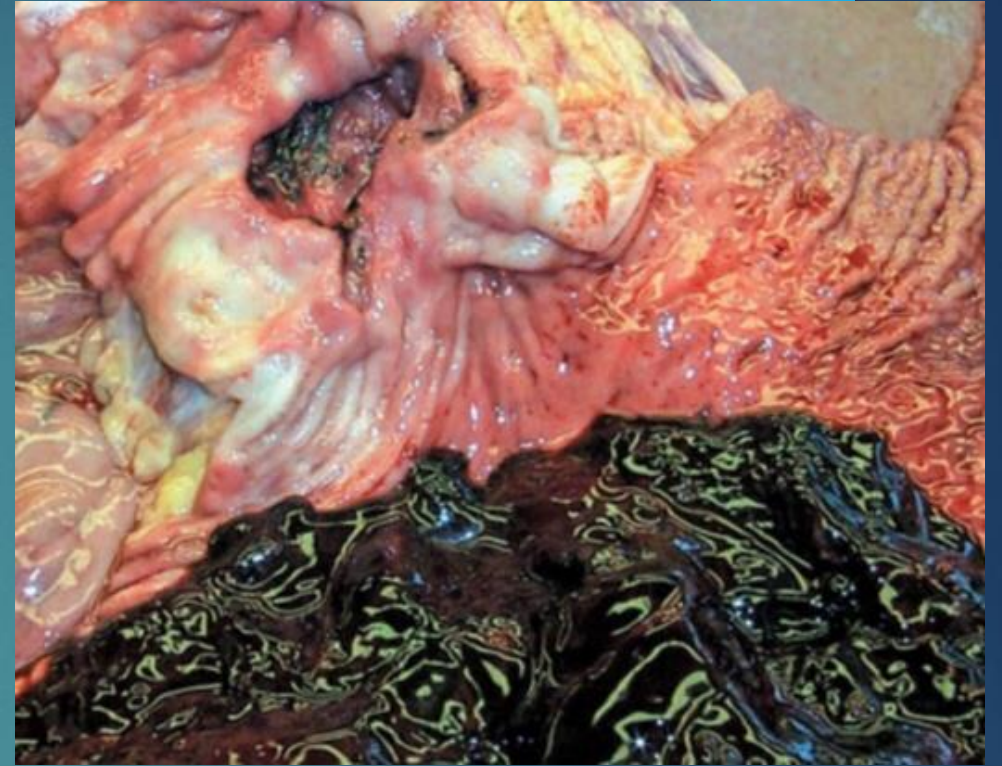
1-Massive hemorrhage

2-Peritonitis

3-Mesenteric thrombosis and embolism

The main causes of sudden death in the gastrointestinal system are predominantly **vascular** in nature, E.g. Severe bleeding from:

- Gastric or duodenal peptic **ulcers**
- Esophageal **varices** in patients with liver cirrhosis



Massive haemorrhage from erosion of blood vessels in the base of this peptic gastric ulcer.

Mesenteric thrombosis and embolism, usually related to aortic or more generalized atherosclerosis, may result in **infarction** of the gut; a **rapid but not sudden** death is expected if the infarction remains undiagnosed. Intestinal infarction owing to a strangulated hernia, or obstruction owing to torsion of the bowel as a consequence of adhesions can also prove rapidly fatal .



Massive haemorrhage from erosion of blood vessels in the base of this peptic gastric **ulcer**.

Peritonitis, following perforation of a peptic ulcer, diverticulitis or perforation at the site of a colonic tumor for example, can be rapidly fatal if not treated. Many of these conditions present as sudden death in elderly people because they cannot, or will not, seek medical assistance at the onset of the symptoms, and are then unable to do so as their condition worsens.



Peritonitis

Gynecological Conditions

Causes:

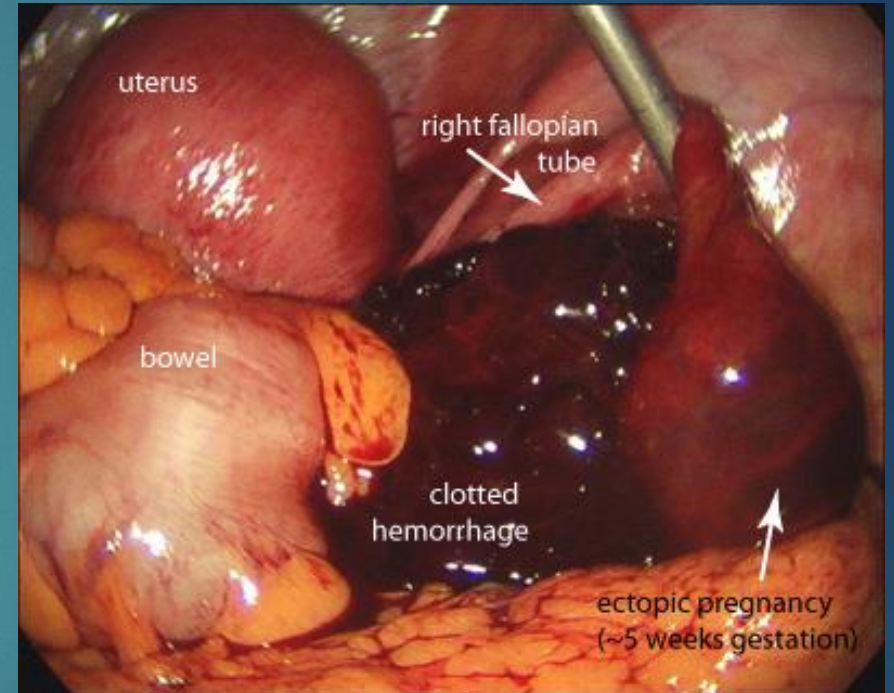
1-Ruptured tubal ectopic pregnancy

2-Ruptured Uterus

3-Air embolism

4-Amniotic fluid embolism

5-Induced abortions



Ruptured tubal ectopic pregnancy is an obstetric emergency that can end in death from intraperitoneal bleeding unless rapidly treated by surgical intervention

Deaths associated with pregnancy (Maternal Death)

- ▶ **Maternal deaths:** Deaths of women while pregnant or within 42 days of the end of the pregnancy from any cause related to or aggravated by the pregnancy or its management, **but not from** accidental or incidental causes, and is classified into direct and indirect:
 1. **Direct Deaths:** resulting from obstetric complications of the pregnant state (pregnancy, labor and puerperium), from interventions, omissions, incorrect treatment or from a chain of events resulting from any of the above.
 2. **Indirect Deaths:** resulting from previous existing disease, or disease that developed during pregnancy and which was not due to direct obstetric causes, but which was aggravated by the physiologic effects of pregnancy.

Negative Autopsy

Cases where no apparent cause of death can be found after performing a full autopsy with full investigations.

Negative Autopsy Causes

- ❑ Endocrinopathies (DKA, hypoglycemia, thyroid storm, adrenocortical insufficiency)
- ❑ Electrolyte abnormalities.
- ❑ Cardiac dysrhythmia : channelopathies
- ❑ Other: Seizure disorder, anaphylaxis, Neuroleptic malignant syndrome, Serotonin syndrome.